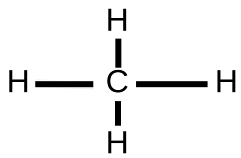
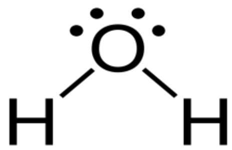
Demonstrate understanding of bonding, structure, properties and energy changes
AS91164

ANSWER ONE (Question p2)

(a)

Molecule	CH4	H_2O	N_2
Lewis structure			

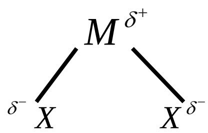
(b) BF_3 is trigonal planar, as BF_3 has three areas of electron density (AED) around the central B atom and all bonding is in pairs. To minimise repulsion the AED will orientate to be as far apart as possible so will be 120^o between each bond.
PF_3 will be a trigonal pyramid. This is due to the molecule having four AED with three bond areas and one lone pair. This is a tetrahedral arrangement but with the lone pair it is trigonal pyramid. Bond angle will be $\angle 109^o$ as all areas of electron density orientate to minimise repulsion.

(c) (i) Polar
NH_3 is polar as it contains polar bonds due to differing electron negativity of the N and H. The molecule is a trigonal pyramid so the bonds are asymmetrically arranged around the central atom so polarities of bonds do not cancel and the whole molecule is polar.

(ii)
Polar: bent
Non-polar: linear

$^{\delta-}X - M^{\delta+} - X^{\delta-}$

Linear MX_2



Bent MX_2

M-X bonds are polar for both molecules with X having higher electronegativity it will carry a partial negative charge.
In linear MX_2 the negatively charged X atoms are arranged symmetrically and so negative sharges cancel, leaving the molecule non-polar.
Bent MX_2 bonds are arranged asymmetrically and so charges do not cancel. The whole molecule is polar.

ANSWER TWO (Question p3)

(a)

Substance	Type of Substance	Type of particle	Attactive forces between particles
C*(s)* (graphite)	Giant network covalent	Atom	Covalent bonds
Cl_2(*s*) (chlorine)	Molecular	Molecule	Weak Intermolecular forces
$CuCl_2$(*s*) (copper chloride)	Ionic solid	Ions	Ionic bonding
Cu(*s*) (copper)	Metallic	Atoms	Metallic bonds

(b) (i) Copper chloride is an ionic solid made up of a 3-D lattice of Cu^{2+} and Cl^- ions. These are strongly attracted to each other. The force/ energy needed to break the bonds between Cu^{2+} and Cl^- in the 3D structure is high and therefore has a high melting point. The forces that hold Cl_2 together are weak intermolecular forces and are easily broken. So it has low melting and boiling points.

(ii) Copper is made up of positive nuclei held together by a sea of delocalised valence electrons. A sea of electrons is mobile so can conduct electricity. Metallic bonding between positive nuclei and delocalized electrons is non-directional, meaning layers can slide in any direction without bonds being broken. This means metals are malleable and ductile.

Graphite is made up of C atoms covalently bonded to three other C atoms in a 2D network. Layers of 2D networks are held together by weak Intermolecular forces. The free valence electron of C atom is located between layers so graphite can conduct electricity. Layers of graphite can slide over each other due to weak intermolecular forces and so can be used as lubricants, but covalent bonds are strong and can not be broken so graphite is not ductile or maliable.

(c)

Bonds broken		Bonds made	
C-H	414	C-Cl	324
Cl-Cl	242	Cl-H	431

Σ Bond broken 656 kJ mol-1 Bond made -755 kJ mol^{-1}

$\Delta_r H$ = 656 – 755 = -99kJ mol^{-1}

ANSWER THREE Question p4)

(a) - endothermic
- gets colder

$\Delta_r H$ is positive more energy is required to break the NH_4^+ NO_3^- bonds than released. This energy is absorbed from the surrounding water in the beaker so it gets colder.

(b) (i) exothermic
$\Delta_r H^o$ is negative.

(ii) $\Delta_r H^o$ -2820kJ mol^{-1}

$$\frac{9800kJ}{2820kJ\ mol^{-1}} = 3.48\ mol$$

(c) (i) endothermic
Energy is required to break intermolecular forces between liquid butane molecules.

(ii) $n(C_4H_0) = \frac{100g}{58.1gmol^{-1}} = 1.721mol$

$1.72mol$ releases 4970kJ

$1mol = \frac{4960kJ}{1.72mol}$

$\Delta H^o = -2881.76kJmol^{-1}$

or $2881kJ$ of energy release when 100g combusted

(d) ① $Fe_3O_4(s) + 8Al(s) \rightarrow 4Al_2O_3(s) + 9Fe(s)$ $\Delta_r H^o = -2248kJmol^{-1}$

② $Fe_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Fe(s)$ $\Delta_r H^o = -851kJmol^{-1}$

Moles of Fe produced

$2000g / 55.9gmol^{-1} = 35.778mol$

Making Fe the subject of EQ①and②

① $\frac{1}{3}Fe_3O_4 + \frac{8}{9}Al \rightarrow \frac{4}{9}Al_2O_3 + Fe(-372kJmol^{-1})$

② $\frac{1}{2}Fe_2O_3 + Al \rightarrow \frac{1}{2}Al_2O_3 + Fe(-425.5kJmol)$

Moles of Fe produced

$2000g / 55.9gmol^{-1} = 35.778mol$

① energy released if 35.778 mol was produced for Fe_3O_4

-372kJmol^{-1} × 35.778 mol

-13309.5kJ

② energy released if 35.778 mol was produced from Fe_2O_3

-425.5kJ mol^{-1} × 35.778 mol

-15223.6kJ

Fe_2O_3 releases more energy when 2.00kg of Fe is produced.